Phys 3150/5190 Project Design Assignment

Due Wednesday, October 10

These questions all relate to understanding the design of our instrumentation amplifier project. I will later provide a common design for everyone to use, to avoid design problems and to make grading the project easier.

1. An important characteristic of any differential amplifier is the common mode rejection ratio (CMRR). In general, a two-input amplifier will have an output expressible as

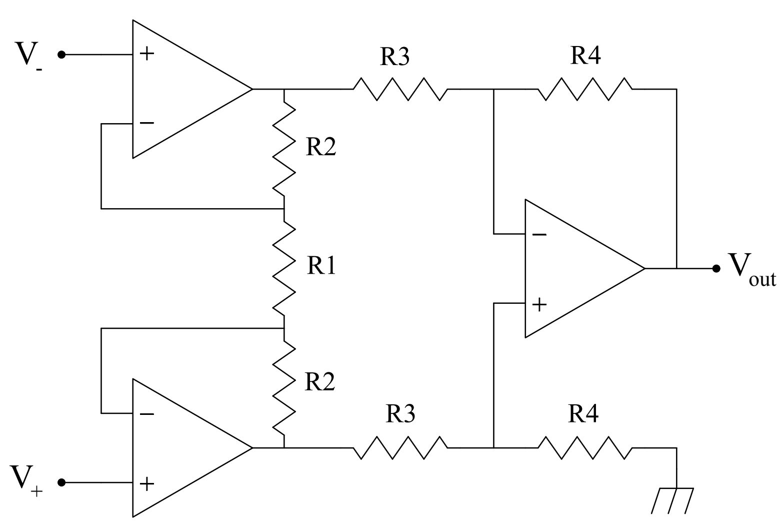
$$V_{\text{out}} = G_{\text{diff}}(V_+ - V_-) + \frac{G_{\text{com}}}{2}(V_+ + V_-).$$

Here G_{diff} is the differential gain and G_{com} is called the common-mode gain. Ideally, an instrumentation amplifier has $G_{\text{com}} = 0$, but no circuit is perfect. The CMRR is therefore defined by

$$\text{CMRR} = \left| \frac{G_{\text{diff}}}{G_{\text{com}}} \right|,$$

usually expressed in dB. A larger CMRR indicates greater immunity to common-mode voltage variations. If a particular circuit has $V_{\text{out}} = AV_+ - BV_-$, what is its CMRR in terms of A and B? Evaluate the CMRR (in dB) for an amplifier with $A = 100.0$ and $B = 100.1$.

2. A good-quality instrumentation amplifier can be constructed using three op-amps in the circuit shown. Analyze this circuit to determine the output voltage in terms of the two input voltages and the various resistor values. Your result should indicate that the CMRR is infinite (since $G_{\text{com}} = 0$). What are some practical limitations that might lead to a finite CMRR in a real three op-amp circuit?



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3. When possible, it is better to use an integrated circuit than to construct a circuit of your own. Many instrumentation amplifier ICs are commercially available. Selecting which chip to use can be challenging.

A good place to start is the DigiKey website (www.digikey.com), which has a helpful search interface. Go there and search for an instrumentation amplifier. You will get a list of categories, from which you should select 'Linear - Amplifiers - Instrumentation, OP Amps, Buffer Amps.' This presents you with a set of property selection menus. Use these to find an instrumentation amplifier with the following characteristics:

a. In stock (so you can get it quickly).

b. Rail-to-rail output (meaning that the output range extends all the way to the supply levels. This is useful because your device will be battery operated with ±9 V supply voltages.)

c. Through-hole mounting (vs. surface mounting. Through-hole mounting is what we have been using in class; it is much easier to solder than surface mounting.)

d. Dual power supply operation ranging from ±5 V or lower to ±15 V or higher. (We want the circuit to work with 9 V batteries but also with standard ±15 V supplies).

What chip(s) can you find that meet these specifications, and what are their costs?

4. One of the chips you found in (3) should be the AD627ANZ. Click on its part number and find the data sheet for the chip. Use the data sheet to determine:

a. What is the amplifier's 3-dB bandwidth at a gain of 100×?

b. What is its dc CMRR at a gain of 100×?

c. How much current can the chip output?

Draw a circuit showing how to wire up the AD627 chip to provide 100× gain. The diagram should show what signals and/or components should be connected to each pin.